

WHAT IS CLAIMED IS:

1. In a wireless communication system comprising at least two Base Stations, at least one Switch in communication with the Base Stations, a method of communicating between mobile units and the Base Stations comprising:

dividing a short-range communication protocol into a low-level protocol for performing tasks that require accurate time synchronization and a high-level protocol which does not require accurate time synchronization; and

for each connection of a mobile unit with a Base Station, running an instance of the low-level protocol at the Base Station connected with the mobile unit and running an instance of the high-level protocol at the Switch.

2. Method, according to claim 1, wherein:

the low-level protocol comprises procedures selected from the group consisting of control and modulation of RF signals transmitted to the mobile unit by the Base Station, frequency hopping, error correction, accurate time synchronization, device address, rough Time Of Day (TOD), voice channel allocation, forward error correction parameters, encryption keys, authentication keys, voice coding, device addressing, address of a parked mobile unit, definition of an asynchronous data link, and data FIFOs; and

the high level protocol comprises procedures selected from the group consisting of procedures for **link setup and control**, high-level protocol multiplexing, packet segmentation and re-assembly, quality of service management, service discovery, emulation of serial port over a logical link manager, interoperability for applications over Bluetooth and infra-red protocols, call control signaling and establishment of speech and data calls between mobile units, interoperability for Bluetooth wireless technology with PPP as communication bearer for wireless application protocol (WAP), command interface to a base-band controller and link manager, access to status information,

discovering available services, cordless telephony, supporting intercom features in handsets, emulation of serial port, supporting the use of a headset, supporting dial up networking, supporting fax transmission and reception, defining how mobile units can access a LAN with PPP, defining generic object exchange, supporting an object push model, supporting file transfer, and synchronizing the mobile units.

3. Method, according to claim 1, further comprising:

using a real time multi-tasking operating system in order to allow handling of many instances of the protocols simultaneously in the Base Stations and in the Switch.

4. Method, according to claim 1, wherein:

the Switch handles routing of data from the high-level protocols to the low-level protocols, and from the low-level protocols to the high-level protocols.

5. Method, according to claim 1, wherein:

the mobile unit is equipped with a short-range wireless communication transmitter/receiver.

6. Method, according to claim 1, wherein a mobile unit is a device selected from the group consisting of:

telephone handset, standard cordless telephone handset, cellular telephone handset, personal data device, personal digital assistant (PDA), computer, laptop computer, e-mail server, a device utilizing point-to-point protocol (PPP) to the Internet via a central remote access server, a headset, a personal server, a wearable computer, a wireless camera, and a mobile music player.

7. Method, according to claim 1, further comprising:

providing communication links between the Base Stations, wherein the communication links between the Base Stations are selected from the group consisting of RF links and land lines; and

transferring connection status information and synchronization information between the Base Stations over the communications links.

8. Method, according to claim 1, wherein:

the Base Stations and the Switch are connected via a wired or wireless local area network (LAN).

9. Method, according to claim 1, wherein:

a first plurality of Base Stations are connected to a first Switch;

a second plurality of Base Stations are connected to a second Switch;

the Switches maintain status tables for calls and connections that they are handling, and maintain copies of each other's status tables; and

when a Switch updates one of its status tables, it sends the updated status table to the other Switches.

10. Method, according to claim 1, wherein:

the wireless communication system comprises a wireless private branch exchange (**WPBX**) handling calls from mobile units comprising handsets.

11. Method, according to claim 10, further comprising:

in the Switch, maintaining a table of calls being handled by the WPBX, comprising information selected from the group consisting of a unique Call Identification number for each active call being handles by the WPBX, the origin of the call, the destination of the call, Calling Number Identification (CNID), Destination Number (DN), Originating Base Station Identification, Destination Base Station Identification, Status of

call, information for billing, and information for performance analysis.

12. Method, according to claim 10, further comprising:

in the Switch, for each call, maintaining a table of connections comprising information selected from the group consisting of Handset ID, Current Base Station ID, handle of high-level protocols, handle of low-level protocols, Number of candidate Base Stations for handoff, List of candidate Base Stations for handoff, and List of handoff status for each candidate Base Station.

13. In a wireless communication system comprising a Base Station connected with a mobile unit, a method of synchronizing at least one neighboring Base Station to the Base Station connected with the mobile unit comprising:

from the Base Station connected with the mobile unit, sending call parameters and rough synchronization information to the at least one neighboring Base Station; and

at the at least one neighboring Base Station, monitoring transmissions of at least one of:

the Base Station connected with the mobile unit;

the mobile unit; and

a beacon signal from a beacon transmitter which is within range of the at least one neighboring Base Station and the Base Station connected with the mobile unit.

14. Method, according to claim 13, wherein the mobile unit is a device selected from the group consisting of:

telephone handset, standard cordless telephone handset, cellular telephone handset, personal data device, personal digital assistant (PDA), computer, laptop computer, e-mail server, a device utilizing point-to-point protocol (PPP) to the Internet via a central remote access server, a headset, a personal server, a wearable computer, a wireless camera, and a mobile music player.

15. In a wireless communication system comprising a plurality of Base Stations and at least one Switch in communication with the Base Stations, a method of synchronizing at least one neighboring Base Station to a Base Station connected with a mobile unit comprising:

from the Base Station connected with the mobile unit, periodically transmitting during a selected time interval with higher transmission power than during normal transmission; and

receiving the transmission with higher transmission power at the least one neighboring Base Station.

16. Method, according to claim 15, wherein:

the selected time interval is a synchronization hop in a series of periodic hops; and

the increased transmission power during the synchronization hop is at least twice as great as the normal transmission power.

17. Method, according to claim 15, wherein:

the selected time interval is a synchronization hop in a series of periodic hops; and

the synchronization hop is transmitted at a different frequency than the remaining periodic hops.

18. Method, according to claim 15, wherein:

the mobile unit is equipped with a short-range wireless communication transmitter/receiver.

19. Method, according to claim 15, wherein the mobile unit is a device selected from the group consisting of:

telephone handset, standard cordless telephone handset, cellular telephone

handset, personal data device, personal digital assistant (PDA), computer, laptop computer, e-mail server, a device utilizing point-to-point protocol (PPP) to the Internet via a central remote access server a headset, a personal server, a wearable computer, a wireless camera, and a mobile music player.

20. Method, according to claim 15, further comprising:
  - providing communication links between the Base Stations, wherein the communication links between the Base Stations are selected from the group consisting of RF links and land lines; and
  - transferring connection status information and rough synchronization information between the Base Stations over the communications links.
21. Method, according to claim 15, wherein:
  - the Base Stations and the Switch are connected via a wired or wireless local area network (LAN).
22. Method, according to claim 15, wherein:
  - a first plurality of Base Stations are connected to a first Switch;
  - a second plurality of Base Stations are connected to a second Switch;
  - the Switches maintain status tables for calls and connections that they are handling, and maintain copies of each other's status tables; and
  - when a Switch updates one of its status tables, it sends the updated status table to the other Switches.
23. Method, according to claim 15, wherein:
  - the wireless communication system comprises a wireless private branch exchange (WPBX) handling calls from mobile units comprising handsets.

24. Method, according to claim 23, further comprising:

in the Switch, maintaining a table of calls being handled by the WPBX, comprising information selected from the group consisting of a unique Call Identification number for each active call being handles by the WPBX, the origin of the call, the destination of the call, Calling Number Identification (CNID), Destination Number (DN), Originating Base Station Identification, Destination Base Station Identification, Status of call, information for billing, and information for performance analysis.

25. Method, according to claim 23, further comprising:

in the Switch, for each call, maintaining a table of connections comprising information selected from the group consisting of Handset ID, Current Base Station ID, handle of high-level protocols, handle of low-level protocols, Number of candidate Base Stations for handoff, List of candidate Base Stations for handoff, and List of handoff status for each candidate Base Station.

26. In a wireless communication system comprising a Base Station connected with a mobile unit, a method of detecting the presence of a specific mobile unit in a coverage area of at least one neighboring Base Station, comprising:

the Base Station connected with the mobile unit provides, to the at least one neighboring Base Station, information about the connection with the mobile unit, including rough TOD and a device address for the mobile unit;

at the at least one neighboring Base Station, receiving information and generating a list of frequencies in which the mobile unit is likely to transmit; and

at the at least one neighboring Base Station, checking for a signal transmitted by the mobile unit.

27. Method, according to claim 26, further comprising:

at the neighboring Base Station, monitoring frequencies that are not

blocked by interferences

28. Method, according to claim 27, further comprising:

for each frequency that is monitored, maintaining a histogram of a number of hops that have been detected in a certain duration of time, and their average signal-to-noise ratios.

29. Method, according to claim 28, further comprising:

determining a measure of spectral cleanness of a frequency being monitored as a function of signal-to-noise ratios (SNRs) of the hops.

30. Method, according to claim 29, further comprising:

monitoring a group (M) of frequencies that have a best cleanness measure most of the time.

31. Method, according to claim 30, further comprising:

periodically monitoring a frequency which is not in the group of frequencies having the best cleanness measure.

32. Method, according to claim 26, wherein the mobile unit is a device selected from the group consisting of:

telephone handset, standard cordless telephone handset, cellular telephone handset, personal data device, personal digital assistant (PDA), computer, laptop computer, e-mail server, a device utilizing point-to-point protocol (PPP) to the Internet via a central remote access server, a headset, a personal server, a wearable computer, a wireless camera, and a mobile music player.



33. Method, according to claim 26, further comprising:  
providing communication links between the Base Stations, wherein the communication links between the Base Stations are selected from the group consisting of RF links and land lines; and  
transferring connection status information and rough synchronization information between the Base Stations over the communications links.
34. Method, according to claim 26, wherein:  
the Base Stations and the Switch are connected via a wired or wireless local area network (LAN).
35. Method, according to claim 26, wherein:  
the wireless communication system comprises a wireless private branch exchange (**WPBX**) handling calls from mobile units comprising handsets.
36. A method for detecting a mobile unit by a Base Station, wherein frequency-hopping is used to communicate between Base Stations and mobile units, comprising:  
at a Base Station that is connected to a mobile unit, periodically yielding a hop; and  
during the hop which has been yielded by the Base Station connected with the mobile unit, communicating with the mobile unit from at least one neighboring Base Station.
37. Method, according to claim 36, further comprising:  
at neighboring Base Stations that are not close to each other, using the same hop to communicate with the mobile unit; and  
at neighboring Base Stations which are close to one another, using different hops to communicate with the mobile unit.

38. In a wireless communication system comprising a Base Station connected with a mobile unit, a method of detecting a handset by at least one Base Station which is waiting for the mobile unit to enter its coverage area, comprising:

from the at least one Base Station waiting for the mobile unit to enter its coverage area and the Base Station connected with the mobile unit, sending a PING command to the mobile unit; and

at the Base Station waiting for the mobile unit to enter its coverage area, receiving an ECHO reply from the mobile unit.

39. Method, according to claim 38, further comprising:

from the Base Station waiting for the mobile unit to enter its coverage area, sending the PING command during a time interval that the Base Station connected with the mobile unit has yielded.

40. Method, according to claim 38, further comprising:

at each Base Station receiving the ECHO response, measuring the quality of the ECHO response and reporting the quality measurements to a Switch connected to the Base Stations.

41. Method, according to claim 38, further comprising:

measuring the quality of each ECHO response by a technique selected from the group consisting of energy level measurement, signal-to-noise ratio (SNR) measurement, packet loss ratio, and bit error rate measurement (BER).

42. Method, according to claim 38, wherein:

the PING command comprises data fields selected from the group consisting of a device address for the mobile unit, an identifier for the mobile unit, a message length, and data; and

the ECHO response comprises data fields selected from the group consisting of an identifier for the mobile unit, a message length, and data.

43. Method, according to claim 38, further comprising:

at each Base Station, maintaining information about connections between mobile units and neighboring Base Stations, wherein the information is selected from the group consisting of connection number, handset ID, Base Station ID, handoff status and handset detection status.

44. Method, according to claim 43, wherein the handset detection status information comprises information selected from the group consisting of number of successful PING, time of last successful PING, quality measurements for successful PINGs.

45. Method, according to claim 38, wherein the mobile unit is a device selected from the group consisting of:

telephone handset, standard cordless telephone handset, cellular telephone handset, personal data device, personal digital assistant (PDA), computer, laptop computer, e-mail server, a device utilizing point-to-point protocol (PPP) to the Internet via a central remote access server, a headset, a personal server, a wearable computer, a wireless camera, and a mobile music player.

46. Method, according to claim 38, further comprising:

providing communication links between the Base Stations, wherein the communication links between the Base Stations are selected from the group consisting of RF links and land lines; and

transferring connection status information and rough synchronization information between the Base Stations over the communications links.

47. Method, according to claim 38, wherein:

the wireless communication system comprises a wireless private branch

exchange (WPBX) handling calls from mobile units comprising handsets.

48. In a wireless communication system comprising at least two Base Stations, at least one Switch in communication with the Base Stations, and at least one mobile unit, a method of handing off the mobile unit from a Base Station communicating with the mobile unit and a neighboring Base Station, comprising:

smoothing a plurality of signals received from a handset by a plurality of Base Stations;

comparing the signals with one another; and

selecting a Base Station for handoff based on signal quality.

49. Method, according to claim 48, wherein:

the signals are compared by computing an average signal quality received from a given Base Station over a time interval encompassing subsequent signals from the given Base Station.

50. Method, according to claim 48, further comprising:

comparing the signals only during times in which the signal was received by more than one Base Station.

51. Method, according to claim 48, wherein the signal quality is based on a measurement selected from the group consisting of energy level, signal-to-noise ratio (SNR), packet loss ratio, and bit error rate (BER).

52. Method, according to claim 48, wherein:

the Base Stations communicate with the mobile units in hops;

the method further comprising:

prior to comparing the signals, aligning in time the measurements of the same hops.

53. Method, according to claim 52, wherein:  
the measurements are averaged over a number (X) of hops

54. Method, according to claim 48, wherein the mobile unit is a device selected from the group consisting of:

telephone handset, standard cordless telephone handset, cellular telephone handset, personal data device, personal digital assistant (PDA), computer, laptop computer, e-mail server, a device utilizing point-to-point protocol (PPP) to the Internet via a central remote access server, a headset, a personal server, a wearable computer, a wireless camera, and a mobile music player.

55. Method, according to claim 48, further comprising:

providing communication links between the Base Stations, wherein the communication links between the Base Stations are selected from the group consisting of RF links and land lines; and

transferring connection status information and synchronization information between the Base Stations over the communications links.

56. Method, according to claim 48, wherein:

the Base Stations and the Switch are connected via a wired or wireless local area network (LAN).

57. Method, according to claim 48, wherein:

the wireless communication system comprises a wireless private branch exchange (**WPBX**) handling calls from mobile units comprising handsets.

58. In a wireless communication system comprising at least two Base Stations and at least one Switch in communication with the Base Stations, a method of performing handoff of a session from a Base Station connected with a mobile unit to a neighboring Base Station, wherein an instance of a low-level communications protocol is running at the Base Station connected with the mobile unit, comprising:

at the Switch, determining when to perform handoff to a selected one of the neighboring Base Stations;

at the selected one of the neighboring Base Stations, creating a copy of the low-level communications protocol, including at least a synchronized time of day (TOD) parameter;

from the Switch, sending a command to stop communication with the mobile unit at a specified TOD to the Base Station connected with the mobile unit and sending a command to start communication with the mobile unit at the specified TOD to the selected one of the neighboring Base Stations; and

updating session status tables in the Switch and in the Base Stations.

59. Method, according to claim 58, wherein:

the session is selected from the group consisting of phone call and data link.

60. Method, according to claim 58, wherein:

the low-level communications protocol comprises procedures selected from the group consisting of control and modulation of RF signals transmitted to the mobile unit by the Base Station, frequency hopping, error correction, accurate time synchronization, device address, rough Time Of Day (TOD), voice channel allocation, forward error correction parameters, encryption keys, authentication keys, voice coding, device addressing, address of a parked mobile unit, definition of an asynchronous data link, and data FIFOs.

61. Method, according to claim 58, wherein:  
the mobile unit is equipped with a short-range wireless communication transmitter/receiver.
62. Method, according to claim 58, wherein the mobile unit is a device selected from the group consisting of:  
telephone handset, standard cordless telephone handset, cellular telephone handset, personal data device, personal digital assistant (PDA), computer, laptop computer, e-mail server, a device utilizing point-to-point protocol (PPP) to the Internet via a central remote access server, a headset, a personal server, a wearable computer, a wireless camera, and a mobile music player.
63. Method, according to claim 58, further comprising:  
providing communication links between the Base Stations, wherein the communication links between the Base Stations are selected from the group consisting of RF links and land lines; and  
transferring connection status information and synchronization information between the Base Stations over the communications links.
64. Method, according to claim 58, wherein:  
the Base Stations and the Switch are connected via a wired or wireless local area network (LAN).
65. Method, according to claim 58, wherein:  
the wireless communication system comprises a wireless private branch exchange (WPBX) handling calls from mobile units comprising handsets.
66. In a wireless communication system comprising a Base Station

connected with a mobile unit, a method of detecting and synchronizing with the mobile unit prior to receiving a handoff of a session with the mobile unit, comprising:

from the Base Station connected with the mobile unit, sending rough synchronization information to at least one neighboring Base Station;

at the neighboring Base Station, performing a wide-range search for "target" signals having the correct timing for a mobile unit, based on the rough synchronization information provided by the Base Station which is connected with the mobile unit;

narrowing the search for an actual signal from the mobile unit;

acquiring the target signal; and

synchronizing the neighboring Base Station to the Base Station connected with the mobile unit.

67. Method, according to claim 66, wherein:

the mobile unit is equipped with a short-range wireless communication transmitter/receiver.

68. Method, according to claim 66, wherein the mobile unit is a device selected from the group consisting of:

telephone handset, standard cordless telephone handset, cellular telephone handset, personal data device, personal digital assistant (PDA), computer, laptop computer, e-mail server, a device utilizing point-to-point protocol (PPP) to the Internet via a central remote access server a headset, a personal server, a wearable computer, a wireless camera, and a mobile music player.

69. Method, according to claim 66, further comprising:

providing communication links between the Base Stations, wherein the communication links between the Base Stations are selected from the group consisting of RF links and land lines; and

transferring connection status information and rough synchronization



information between the Base Stations over the communications links.

70. Method, according to claim 66, wherein:

the Base Stations and the Switch are connected via a wired or wireless local area network (LAN).

71. Method, according to claim 66, wherein:

the wireless communication system comprises a wireless private branch exchange (WPBX) handling calls from mobile units comprising handsets.

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